A TREATISE

ON

THE ANEROID,

A NEWLY INVENTED PORTABLE BAROMETER.

WITH

A SHORT HISTORICAL NOTICE ON BAROMETERS IN GENERAL,
THEIR CONSTRUCTION AND USE.

BY

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BY SPECIAL APPOINTMENT
CHRONOMETER AND CLOCK MAKER TO HER MAJESTY THE QUEEN, AND HIS ROYAL HIGHNESS
PRINCE ALBERT;
AND H. I. M. THE EMPEROR OF RUSSIA.

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ON

THE ANEROID BAROMETER.

Previously to describing the construction of the barometer which is announced to the public under the name of the Aneroid,* it has seemed advisable to the author of these pages to offer a short account of the Mercurial Barometer. Although the latter instrument is so common as to be looked upon almost as a piece of furniture, and has become our constant adviser, as indicative of the changes likely to take place in the weather, still, little is generally known of its principle and construction. The reason of this appears to be, that its history is generally contained in elaborate works of reference, such as Encyclopedias, or books on Natural Philosophy, which, either from their bulk, or the technicality of their language, repel the curiosity of the general reader. A concise and plain description of the barometer is further rendered necessary,

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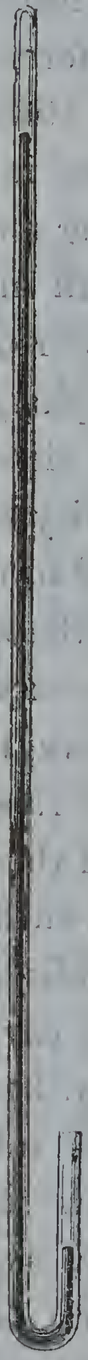
* The author is informed by a literary friend, that this term, concerning which there has been some philological discussion, is said to be derived from three Greek words, ἀ, νηρὸς, and εἶδος, and to signify *a form without fluid.* If so, it does not appear very happily chosen, since it indicates merely what the instrument is *not*, without at all explaining what it *is*.

from the circumstance of the tube and mechanism being generally inclosed in its case, and concealed from observation. But the immediate object of the following prefatory remarks on barometers in general, is to introduce the explanation of a new principle; viz., the employment of a Vacuum-vase, instead of the column of mercury, or any other fluid. History teaches us, there was a time when, even to contemplate a vacuum, would have been to condemn the philosopher to all the horrors of persecution; and we are informed that Galileo dreaded the evils to which an investigation of a vacuum would have exposed him. It is recorded of this great mathematician, that, whilst residing at Florence, he was applied to on the occasion of the Grand Duke's having sunk a deep well, who, when he found that the water would not rise to the top, sent for the philosopher to explain the mystery. Galileo observed that the column of water rose in the pump to about thirty-two feet, and that all attempts to raise it higher by means of the sucker were useless. He therefore concluded that the sucker was not the cause of the water's rising to a given height, as was the opinion at that time, but that the vacuum which was produced by the exhaustion of the air from the tube of the pump by means of the sucker, occasioned the water to rise to a certain height, from a pressure on the surface of the water which was in the well. From this, it is evident that Galileo was aware of the pressure of the atmosphere on the external surface; and this pressure founds the principle of the barometer. Through fear of persecution, however, Galileo kept the discovery to himself until his latter days, when he made it known to his pupil Torricelli, to whose indefatigable exertions we are indebted for the whole theory on which the invention of the barometer rests. Torricelli found, as his master had communicated to him, that the atmospheric pressure on the surface of the water would support a column of water, in a tube closed at the top, to the height of about thirty-two feet; but being sensible that such a column would, from its height, be very ill calculated for conducting his experiments, he concluded that, as a column of mercury was nearly fourteen times heavier than one of water, he could, by employing the former, very greatly facilitate his research. In the year 1643, he accordingly took a glass tube about forty inches in height, and a quarter of an inch in the bore. Having sealed one end by the force of heat, he filled the tube with mercury; then placing his finger at the open end in order to secure the mercury, and inverting the tube, he plunged the extremity, thus secured by his finger, into a cistern containing mercury, and having a certain quantity of water upon its surface. Having passed the open end of the tube through the water, and below the surface of the *mercury*, he withdrew his finger. Upon this, the mercury in the tube instantly fell to about thirty inches above the surface of the mercury in the cistern. On his raising the open end of the tube until it became level with the bottom of the *water*, the mercury instantaneously sank entirely out of the tube; while the water, with the same rapidity, sprang up to the *top* and occupied the *whole* of the cavity. It would, of course, by the laws of specific gravity, have risen to the height of about thirty-two feet, had the tube been sufficiently long. Torricelli then clearly saw that the columns, both of mercury and of water, were supported from the same cause, namely, the atmospheric pressure. He next altered the shape of the glass tube by bending up the lower and open end.

This is the figure of the present tube, as we have it in the Wheel Barometer.

Fig. 1.

TORRICELLIAN TUBE.

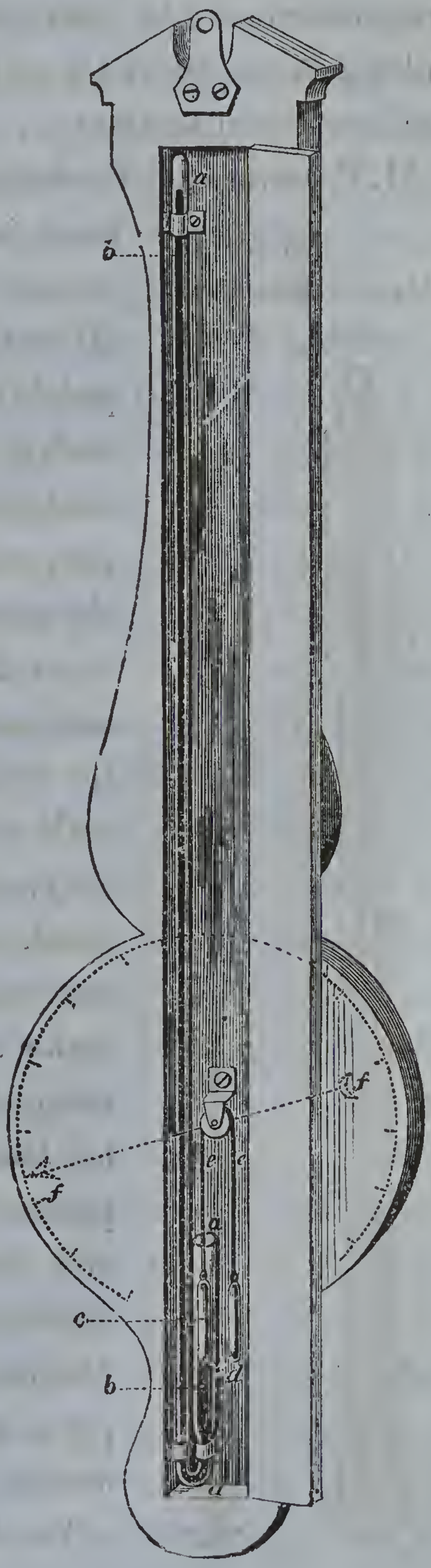


After the publication of Torricelli's experiments in 1645, the field was opened to all philosophers for the practice of every experiment to which the barometer is applicable. Torricelli did not live long to enjoy the fame of his discovery, and died at an early age. To enter into an account of the numerous experiments of distinguished men with the Torricellian tube, would be extending the limits of this paper beyond the object proposed. It may be sufficient for us to know that the principle remains precisely the same. By the barometer, we are enabled to determine the pressure of the atmosphere, which is known to be about 15 lbs. pressure on a square inch. This fact is proved when the air is exhausted, by means of an air-pump, from any glass receiver or air-tight box, similar to the vacuum-vase of the Aneroid. At the earth's surface, where, from the weight of the atmosphere above it, the air is in a state of the greatest compression, a cubic foot of air weighs 1·2857 oz.; and the higher we ascend, the less dense will it become. The barometer will consequently fall, as the elasticity of the air is equal to the weight of the atmosphere above it, and they always balance each other.

The principle of the Torricellian tube having been thus explained, and its power shown of registering the incumbent weight of the atmosphere, it now remains to describe the barometer as it is made for domestic purposes, and as we find it hanging up in most houses, as a standard of reference for changes which are likely to take place in the weather. The first we have to make ourselves acquainted with, is called the Wheel Barometer, in which the peculiar arrangement of the Torricellian tube is the invention of the late eminent philosopher, Dr. Hooke.

a a a, the Torricellian tube; *b b*, the mercury; *c*, a light weight of iron or glass, resting on the top of the mercury; *d*, a lighter weight; *e e*, silk thread which passes over a roller, having a delicate axis. On this axis is fixed the hand *f*. Whenever a decrease of atmospheric pressure takes place, and the vapours, no longer suspended, may be expected to descend in rain, the weight *c* rises, and the smaller weight, *d*, pulls round the hand from "Fair" towards "Change." While the height

Fig. 2.
Wheel Barometer.



of the column in the short leg has risen, that in the long leg, (which in the plain barometer without the wheel is the only one visible,) will proportionably have sunk; and we accordingly say, on looking at the indicating column, that the mercury has *fallen.* Fair weather is, of course, prognosticated by the contrary process: the mercury sinking in the short leg of the tube, and rising in the long one, presented to the eye.

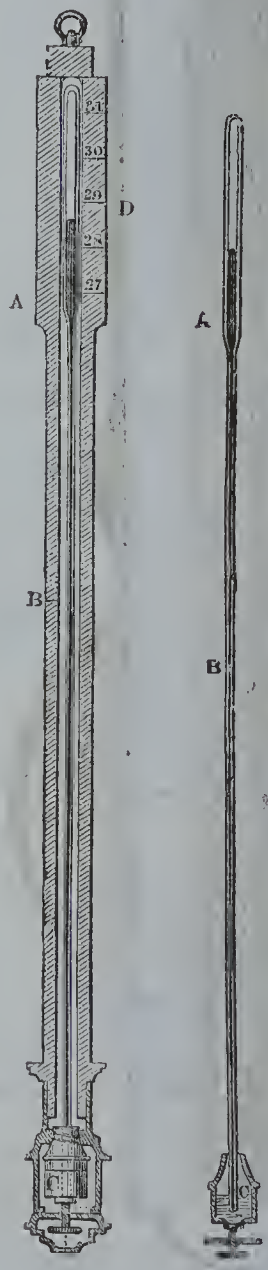


Fig. 3.
MARINE BAROMETER.
No. 1. No. 2.

M. Passement, a French artist, about 1758 first produced what is now called the Marine Barometer. This instrument is familiar to all navigators, being constructed purposely for shipboard. It is evident that such a barometer as has been above described, would not answer the mariner's purpose for two reasons; first, because the mercury would be thrown out at the short leg by the motion of the ship; and, secondly, because the oscillation in the column would be so great, that the scale could not be read off, and the mercury, striking the top of the tube, would break the glass. Under such circumstances, the mariner is compelled to make a shift with a very defective, sluggish instrument; when, in reality, he, above all other men, ought to be in possession of one of the most perfect and sensitive. To substantiate this assertion, we need only describe the Marine Barometer now in use, and supply a drawing from one of the instruments.

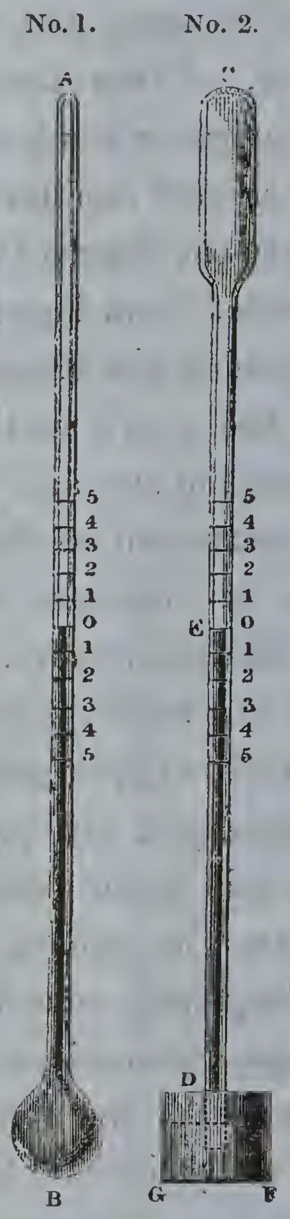
The Marine Barometer, seen at fig. 3,

No. 1, is made with a capillary tube, about twenty-seven inches long, and represented at No. 2, as removed from its case. The lower part of this tube scarcely exceeds the thirtieth part of an inch in diameter, but it terminates at the top A in a larger bore, four or five inches long, and nearly three-tenths of an inch in diameter. From the ivory plate D, parallel with this tube, the navigator reads off the scale, perhaps not knowing that only a small capillary tube extends the whole length downwards to the cistern C, since this tube of diminished bore is concealed from his view by the outer case. This capillary tube, which was intended to counteract the disturbing effect of the ship's motion, is attended with a serious evil; it renders the rise and fall of the mercury in the upper part of the instrument so sluggish, that it does not show any increase or decrease of the column, under an interval of five minutes or more. For example, if you incline the barometer to a nearly horizontal position, until the mercury has risen in the upper part, and then restore it to its vertical position, you will perceive that an interval of several minutes will occur before its original indication is shown. Such are the defects of an instrument which the navigator so frequently consults for his guidance, while he is often, perhaps, unconscious of its labouring under the imperfections to which the foregoing remarks have shown that it is essentially liable. Surely, then, it is a desideratum of the utmost consequence that the barometer for shipboard should be improved.

The next instrument to be described is that which is known at the present time by the name of a Sympiesometer. This was also the invention of the great Dr. Hooke, and preceded his ingenious Wheel Barometer. It consists of two parts. The one (A B) No. 1, is a common spirit thermometer; the other, No. 2, (C D), a tube filled with air from C to E, and from thence, to the end D, with tinged water. The end D is immerged in water of the same colour, contained in the vessel G F, leaving the surface of the water exposed to the pressure of the atmosphere. Now No. 2 will be affected not only by the atmospheric pressure, but also by temperature. The latter will dilate the air included in No. 2 at C E, and by that means drive the water downwards; the former, on the contrary, will press it up higher in the tube. The other, (A B) No. 1, is affected by temperature alone. If, at the time of the formation of these two instruments, their zeros were marked at the same point, the gravity of the external air remaining the same, their indications would be found exactly to correspond: so that if a difference in their indications took place, that difference could be ascribed only to the alteration in the atmospheric pressure upon the surface of the water in the vessel G F. In proportion, therefore, as the difference between the two is greater or less, so is the alteration in the gravity of the air, from what it was when the instruments were first graduated. For instance, when the water in No. 2 stands above the division which corresponds to that which the spirit points to in No. 1, it is an indication that the atmospheric pressure is greater at that time, than it was when the

Fig. 4.

Dr. Hooke's Sympiesometer.

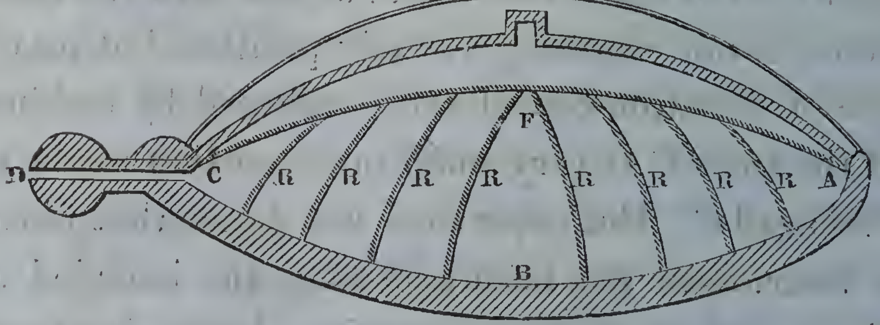


instruments were graduated, and *vice versâ.* This double instrument is not only more useful at sea than the common barometer, as not requiring a steady position, but may have its scale of variation considerably enlarged by making the bore of the tube C D very small in proportion to the capacity of its head C. But experience has shown, that when this double instrument has been kept long, the included air in No. 2 loses somewhat of its elasticity; hence, in process of time, the water stands higher than it ought, and therefore indicates the gravity of the atmospheric air to be greater than it really is. The construction of the Sympiesometer has been improved by different artists; but from the liquids changing their states, and thereby producing an incorrect indication, it is not so generally used on shipboard, as the marine mercurial barometer.

An explanation having been given of the barometers most frequently employed, all of which are, on the principle of the Torricellian tube, constructed with fluids, it is now proposed to describe the Aneroid Barometer. It seems a matter of surprise, that so many distinguished men should have devoted so much time and care to improve the old barometer, constructed with fluids, without even an attempt to supply its place by employing a vacuum-vase; as the latter renders the instrument incalculably more useful, from its portability.

The first paper on the subject of a Vacuum-vase, was published in the "Bulletin des Sciences, Floreal, An. 6," by M. Conté, Professor of the Aërostatical School at Meudon, near Paris. M. Conté, in his balloon ascents during the war in Egypt, found the ordinary barometer subject to so much oscillation that it was useless. He was the inventor of the vacuum-vase, and the following is a copy of his instrument, and the description he gives of it, extracted from the "Bulletin des Sciences, Floreal, An. 6," page 106.

Fig. 5.

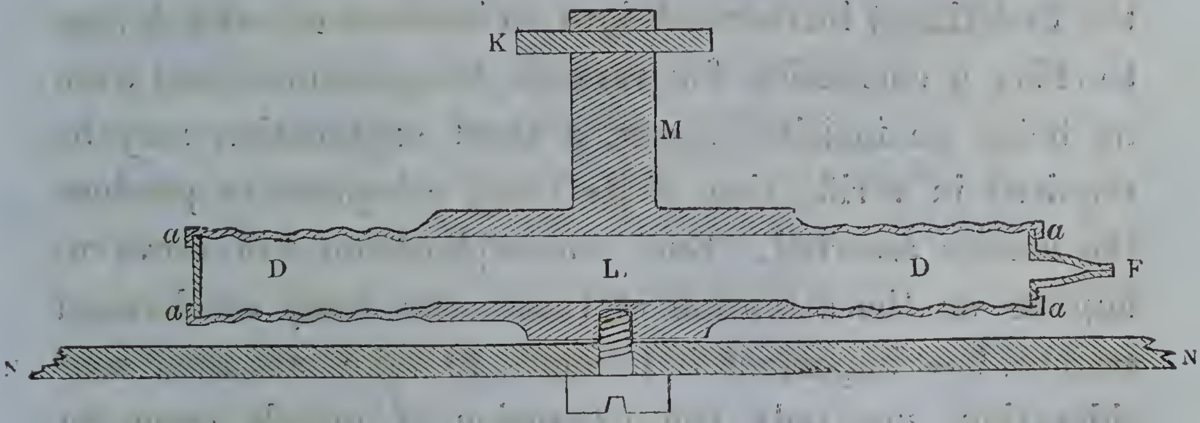


"M. Conté, Professor of the Aërostatical School at Meudon, and now in Egypt, has occupied his attention for some time past in adapting a barometer which, although of a simple contrivance, should be more sensitive than those already in use. We now proceed to explain the first of his discoveries. It is shown in plate 5, fig. 4, and is very like a pocket watch. A B C is a bowl made of strong iron or copper, upon which is a cover, C F A, of a very thin sheet steel, and the edges of which must be fitted with great exactness. The springs, R R, keep the cover at its elevation; and while they regulate its action, the air is pumped out of the bowl, A F C B, through the opening at D. This opening shuts itself so as to be air-tight, and then the whole weight of the atmosphere forces down the flexible bowl, C F A. Now, as the resistance of the springs remains constantly the same, this cover-plate rises or falls as the atmospheric pressure varies; and these variations are shown by means of a hand, securely fastened, which passes backwards and forwards upon a divided plate." The discoverer, however, acknowledges that he was compelled to reject this instrument, on account of the prejudicial influence which the change of temperature had upon it.

From the above diagram, there may be adduced many strong reasons, besides that which M. Conté has stated, to show why he was not successful. The principal one would readily suggest itself to any person of mechanical information. The figure he chose as the object of atmospheric compression is, perhaps, of all forms, the worst adapted for that purpose; viz., an *arch*. That he has recorded the principle cannot be disputed; but when we consider what has been stated relative to the form of his vacuum-vase, to say nothing of its inadequately small dimensions, we must be permitted to question if he ever obtained any practical result. The extreme ingenuity of M. Vidi, the inventor of the instrument about to be described, appears, then, to be in no way disparaged by the claims to the invention of the principle, which have been set up for M. Conté by his friends.

A diagram and explanation of M. Conté's vacuum-vase having been given above, it will be proper to detach and exhibit on paper that of M. Vidi, that the difference between the two may be shown more clearly, and that the ingenious means adopted by M. Vidi to correct for varying temperature, may be the better appreciated.

Fig. 6.



At figure 6 the vacuum-vase is represented in the shape which it presents before it is exhausted by the air-pump; *a a a a* show the turning or lapping over of the thin corrugated diaphragms where they are soldered to the rim; D D is the vacuum-vase; M is the socket, which, being pulled by the pin K, places the vase in a state of tension, whereby it offers resistance to the pressure of the external atmosphere.

Fig. 7.

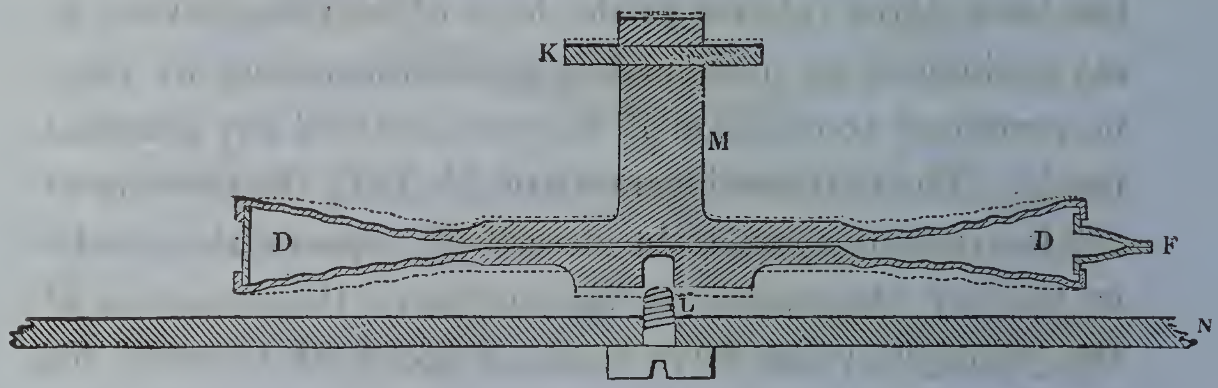


Figure 7 shows the vacuum-vase in a compressed state, after the air has been exhausted by the air-pump, through the tube F. The dotted lines running nearly even with the corrugated surface, are intended to show the position which that surface will assume after the introduction of the gas, which effects a compensation for the results of varying temperature.

From the circumstance of a gas being (perhaps for the first time,) introduced into an instrument, with a view to effect a correction for variable temperatures, and from its being an invisible agent, a short explanation may be required in verification of its being adequate to produce the results asserted. Such an explanation will serve to impress on the attention of those who study mechanical science, how important it becomes to take into their consideration, not only the expansion of metals upon an increase of temperature, but also the loss of elastic force, to which, in a state of tension, they become subject. The student is familiar with tables indicating the expansion of metals; but, even at the present time, no table has been calculated in order to show the loss sustained by elastic bodies when in a state of tension; perhaps no instrument, although made for the express purpose, could exhibit an experiment more satisfactory for the proof of this point than the Aneroid. We are enabled to use it as a pyrometer by applying the heat of a lighted taper to the spring S, figure 9, without communicating that heat to the vacuum-vase. A table of direct expansion would cause us to conclude, that as the spring S would, on being heated, become longer, it would raise the lever C higher; but the experiment above adverted to produces a contrary result, (for the spring S losing its elastic power through heat, is forced down by the atmospheric pressure on the vacuum-vase,) and proves that the loss of elastic force is greater than that of direct expansion. The hand of the Aneroid indicates this, by moving towards the right, or "Set Fair."

We might further suppose that an increase of heat expanding the metal of which the vacuum-vase was made, would proportionately increase its capacity; whereas, the contrary is actually the case;—a conclusion which is proved by heating the vacuum-vase alone. It must be admitted that the metal diaphragms have become both larger and weaker by an increase of temperature, whence the capacity of the vacuum-vase would be rendered greater; but it must be also remembered, that the atmospheric pressure on the surfaces, amounting to a force of 44 lbs., brings the upper and lower diaphragms, thus weakened by heat, closer together, so that the cavity of the vacuum-vase has, in fact, become smaller.

This brings us to the subject of compensation accomplished by gas. On the capacity of the vacuum-vase being diminished by heat, as has been just shown, the gas contained within it is, by the same cause, expanded; and resisting the compressing force of the atmospheric weight upon the diaphragms, keeps them separated at a due distance, and effects the compensation.

As there is no external correction for temperature to be seen in the Aneroid, we will subjoin a convincing proof that the instrument *is* compensated, and that with no ordinary exactness. The following tables have been made by two gentlemen, after a comparison of the Aneroid with two of the most expensive and perfect mercurial barometers to be found in this country. It should be noticed that, in neither case, did the Aneroid derive any assistance by correction for variable temperature.

TABLE I.

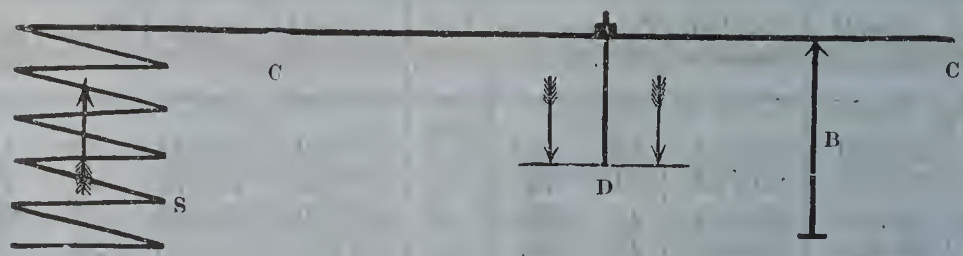
Date. 1848.	Aneroid Barometer.	Mercurial Barometer.	Thermometer.	Date. 1848.	Aneroid Barometer.	Mercurial Barometer.	Thermometer.
Jan.				Feb.			
6	29·67	29·672	45°	1	29·72	29·702	45°
7	29·52	29·526	45	2	30·11	30·091	42
8	29·53	29·527	46	3	30·33	30·344	46
9	29·94	29·950	44	4	30·12	30·116	45
10	30·14	30·152	42	5	30·07	30·072	50
11	30·31	30·304	41	6	30·02	30·046	54
12	30·39	30·358	42	7	29·97	29·975	54
13	30·26	30·240	45	8	29·83	29·840	52
14	30·18	30·170	47	9	29·04	29·056	51
15	29·86	29·860	48	10	28·93	28·944	50
16	29·91	29·905	41	11	29·84	28·832	48
17	29·59	29·590	45	12	29·83	29·815	50
18	29·39	29·400	44	13	30·02	29·098	51
19	29·34	29·358	44	14	29·81	29·822	52
20	29·74	29·746	41	15	29·43	29·466	52
21	29·98	29·996	42	16	29·66	29·676	49
22	30·00	29·997	42	17	30·18	30·168	48
23	30·03	30·016	41	18	30·38	30·368	46
24	30·29	30·270	41	19	29·69	29·712	42
25	30·32	30·298	40	20	29·28	29·328	48
26	30·03	30·025	38	21	29·72	29·752	45
27	29·98	29·915	34	22	29·40	29·428	50
28	29·79	29·772	35	23	28·92	28·947	49
29	29·87	29·860	36				
30	29·60	29·620	46				
31	29·19	29·190	49				

TABLE II.

Date. 1848.	Aneroid Barometer.	Standard Barometer.	Thermometer. Max. & Min.		Date. 1849.	Aneroid Barometer.	Standard Barometer.	Thermometer. Max. & Min.	
Dec. 1	29·400	29·444	43°	34°	Jan. 3	29·450	29·444	23°	14°
2	29·125	29·178	41	31	4	29·475	29·476	31	18
3	29·575	29·624	45	28	5	29·500	29·540	33	28
4	29·025	29·080	47	32	6	29·762	29·780	33	24
5	28·725	28·800	43	35	7	29·800	29·826	33	19
6	29·025	29·100	48	35	8	29·287	29·312	40	28
7	29·250	29·300	50	39	9	29·225	29·250	41	32
8	29·575	29·624	51	40	10	28·887	28·950	44	34
9	29·912	29·920	49	37	11	28·862	28·960	36	32
10	30·100	30·124	49	37	12	29·850	29·900	40	24
11	29·950	29·964	48	36	13	29·487	29·530	49	29
12	29·975	30·004	50	38	14	29·250	29·316	51	45
13	29·875	29·886	51	43	15	29·775	29·834	40	30
14	29·600	29·600	46	37	16	29·712	29·716	45	28
15	29·612	29·620	50	38	17	29·450	29·520	48	31
16	29·575	29·584	47	38	18	29·762	29·800	47	34
17	29·662	29·670	39	34	19	29·675	29·718	43	40
18	29·650	29·650	44	32	20	29·812	29·836	47	39
19	29·575	29·594	45	40	21	30·000	30·050	48	39
20	29·950	29·950	37	36	22	29·712	29·750	43	40
21	30·112	30·114	26	18	23	30·112	30·132	46	34
22	30·112	30·100	29	18	24	30·175	30·176	47	38
23	30·025	30·024	32	19	25	29·887	29·912	49	41
24	29·862	29·850	32	18	26	29·575	29·600	42	43
25	29·662	29·661	35	24	27	29·719	29·750	40	26
26	29·812	29·802	43	38	28	29·100	29·150	39	32
27	29·940	29·942	47	33	29	29·200	29·250	39	29
28	29·815	29·806	47	32	30	29·900	29·904	40	24
29	30·000	30·006	46	32	31	29·900	29·900	40	36
30	29·890	29·896	45	31					
31	29·895	29·922	39	28					

The vacuum-vase is brought into a state of tension by separating the diaphragms, after exhaustion, and placing the pin K on the lever C, as shown in fig. 9. The lever C is then to be placed on its fulcrums, B B, and the other end of the lever C to rest on the top of the spiral spring S. The action of the atmosphere on the vacuum-vase, and the connection of the latter with the spring S, require, as we have before remarked, to be clearly understood, in order to a perfect acquaintance with the principle of the Aneroid. To illustrate this still further, it appears necessary to give a diagram explanatory of the theorem.

Fig. 8.

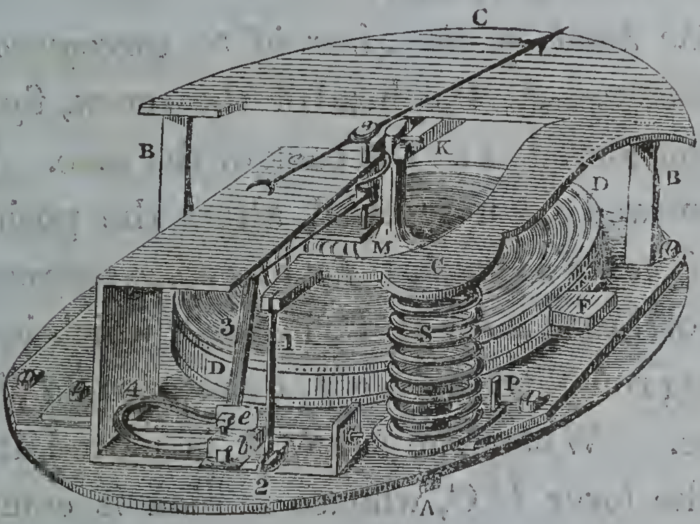


D represents the vacuum-vase. The arrows indicate the downward pressure of the atmosphere, which alone keeps the lever, C, on its fulcrum, B, as well as on the *top* of the spring, S. This spring is compressed by the atmospheric force on the vase; whence it will be seen, that if the vacuum were destroyed in the vase, the lever, C, would instantly fall off its fulcrum, as well as off the top of the spring, S. The lever, C, it may be remarked, is of the second order.

Let us suppose an increase of atmospheric pressure on the vacuum-vase to take place; the fulcrum, B, would remain, of course, firm and unaffected. The surface of the vase, D, would be forced downwards, and the spring, S, at the same instant, still more so; as must be apparent from considering the increased distance of the lever, which in the Aneroid is as six to one.

A few words may be required for the further illustration of this subject. We know that the atmospheric pressure is about 15 lbs. to the square inch. Now the vacuum-vase being $2\frac{1}{2}$ inches in diameter, this surface gives for its product a pressure of about 73 lbs. on the vase; though from many causes, this amount of atmospheric pressure is considerably reduced. In order to ascertain the actual weight produced by the atmosphere upon the surface of the vacuum-vase, recourse was had to an experiment affording positive demonstration. The hook of a steel-yard, or spring weighing-machine, was attached to the upper part of the vase by the pin K, and, on being pulled up to the point parallel to the top of the vase, showed the weight of 44 lbs.; which is, therefore, proved to be the force by which the lever C is kept on its fulcrums B B, and on the top of the spring S.

Fig 9.



It is hoped that the principle of the Aneroid has, from the foregoing explanations, been made sufficiently intelligible, and if so, it will be an easy task to describe the remainder of the mechanism. We will now refer to the perspective drawing of the interior of the machine:—D D, vacuum-vase; C C, lever; to the end of which is attached a vertical *rod*, (1), which merely serves to connect the lever C C with the levers (2 and 3). These levers are connected by a bow-piece, (4). The two square-headed screws at *e b* admit, by screwing or unscrewing them, such an alteration of the distance of leverage, as to allow the hand of the Aneroid to move over a space corresponding with the scale of a standard mercurial barometer. To the end of the lever (3), is attached a light rod, terminating with a piece of fine watch-chain, which is attached to a small roller. On the axis of this roller the hand of the Aneroid is firmly fixed, and kept in its position by means of a flat spiral spring the outer coil of which is seen attached to the axis. This flat spiral spring, which is always in a state of tension, maintains a pressure against the force of the levers, and keeps the hand of the Aneroid in obedience to the indications of the vacuum-vase. Were it not for this spring, the hand *b*, fig. 10, would remain stationary at the point to which it had been propelled.

To set the hand of the Aneroid to correspond with any other Barometer.—A, the head of the screw, figures 9 and 10, to be considered as at the back of the case. This screw A, when screwed or unscrewed, alters the position of the hand, *and is not to be touched for any other purpose.* It acts in a piece of brass, seen at P, in fig. 9, which is prevented from turning round the spring S, by means of a pin inserted in the plate. When the screw A is moved, it raises or depresses the lever C C, whence motion is communicated to the hand.

To register the variations of the Aneroid.—A nut, as seen at O, figure 10, projects through the centre of the glass, to enable the observer to move the gilt index W, beneath it. By this gilt index, the registration of the hand *b* is effected. The two hands having been placed exactly parallel, by turning this nut, and bringing the gilt index W immediately over the hand *b*,—should the latter have subsequently deviated from W, either to the right or the left, the difference will be the result of increased or diminished atmospheric pressure.

Fig. 10.

POPULAR USES OF THE BAROMETER.

STATE OF THE WEATHER.

The construction of the several kind of barometers in general use having been explained previously to that of the Aneroid, that the principle of their different constructions may be made familiar to the ordinary reader; it now seems advisable to offer some remarks for the guidance of those persons who wish to apply the barometer to its most ordinary use: viz., to ascertain what is likely to be the state of the weather. No attempt has been made to enter into a detailed account of the various other purposes to which the man of science may apply this instrument, because, in philosophical experiments, so many calculations require to be made, (such as, allowance for capillary attraction, capacity of the basin containing the mercury, temperature, &c. &c.), that so lengthened an enumeration of particulars would be tedious and unedifying to the general reader. It appears, then, expedient to proceed at once to the cause which produces the varied pressure of the atmosphere on that part of the barometer which actuates the index. This, in the ordinary instrument, will be the mercury; in the Aneroid Barometer, it will be the vacuum-vase. For the clear elucidation of these influencing atmospheric causes, it is impossible to offer any explanation more plain and intelligible than the following remarks of the late eminent Dr. Halley, copied from the Philosophical Transactions of 1767, vol. i., pp. 88—95.

"1. In calm weather, when the air is inclined to rain, the mercury is commonly low.

"2. In serene, good, and settled weather, the mercury is generally high.

"3. Upon very great winds, though they be not accompanied with rain, the mercury sinks lowest of all, with relation to the point of the compass the wind blows upon.

"4. *Cæteris paribus*, the greatest heights of the mercury are found upon easterly and north easterly winds.

"5. In calm frosty weather, the mercury generally stands high.

"6. After very great storms of wind, when the mercury has been low, it generally rises again very fast.

"7. The more northerly places have greater alterations of the barometer, than the more southerly.

"8. Within the tropics, and near them, those accounts we have had from others, and my own observations at St. Helena, make very little or no variation of the height of the mercury in all weathers.

"Hence I conceive that the principal cause of the rise and fall of the mercury, is from the variable winds, which are found in the temperate zone, and whose great unconstancy, here in England, is most notorious.

"A second cause is the uncertain exhalation and precipitation of the vapours lodging in the air, whereby it comes to be at one time much more crowded than at another, and consequently heavier, but this latter in a great measure depends upon the former. Now, from these principles, I shall endeavour to explicate the several phenomena of the barometer, taking them in the same order I laid them down. Thus,—

"1. The mercury's being low inclines it to rain, because, the air being light, the vapours are no longer supported thereby, being become specifically heavier than the medium wherein they floated, so that they descend towards the earth, and in their fall, meeting with other aqueous particles, they incorporate together, and form little drops of rain; but the mercury's being at one time lower than at another, is the effect of two contrary winds blowing from the place where the barometer stands; whereby the air of that place is carried both ways from it, and, consequently, the incumbent cylinder of air is diminished, and accordingly the mercury sinks: As, for instance, if in the German ocean it should blow a gale of westerly wind, and at the same time an easterly wind in the Irish sea; or if in France it should blow a northerly wind, and in Scotland a southerly; it must be granted, that that part of the atmosphere, impendent over England, would thereby be exhausted and attenuated, and the mercury would subside, and the vapours, which before floated in those parts of the air of equal gravity with themselves, would sink to the earth.

"2. The greater height of the barometer is occasioned by two contrary winds blowing towards the place of observation, whereby the air of other places is brought thither and accumulated; so that the incumbent cylinder of air, being increased both in height and weight, the mercury pressed thereby must needs stand high, as long as the winds continue so to blow; and then the air being specifically heavier, the vapours are better kept suspended, so that they have no inclination to precipitate and fall down in drops, which is the reason of the serene good weather which attends the greater heights of the mercury.

"3. The mercury sinks the lowest of all by the very rapid motion of the air in storms of wind. For the tract or region of the earth's surface, wherein the winds rage, not extending all round the globe, that stagnant air which is left behind, as likewise that on the sides, cannot come in so fast as to supply the evacuation made by so swift a current, so that the air must necessarily be attenuated, when and where the said winds continue to blow, and that more or less, according to their violence: add to which, that the horizontal motion of the air being so quick as it is, may, in all probability, take off some part of the perpendicular pressure thereof; and the great agitation of its particles is the reason why the vapours are dissipated, and do not condense into drops, so as to form rain, otherwise the natural consequence of the air's rarefaction.

"4. The mercury stands the highest upon the easterly and north-easterly wind, because in the great Atlantic ocean, on this side the thirty-fifth degree of north latitude, the winds are almost always westerly or south-westerly; so that, whenever here the wind comes at east and north-east, 'tis sure to be checked by a contrary gale as soon as it reaches the ocean; wherefore, according to what is made out in our second remark, the air must needs be heaped over this island, and consequently the mercury must stand high, as often as these winds blow. This holds true in this country, but is not a general rule for others, where the winds are under different circumstances; and I have sometimes seen the mercury here as low as twenty-nine inches upon an easterly wind, but then it blew exceeding hard, and so comes to be accounted for, by what was observed upon the third remark.

"5. In calm frosty weather the mercury generally stands high because (as I conceive) it seldom freezes, but when the winds come out of the northern, and north-eastern quarters; or, at least, unless those winds blow at no great distance off: for the north parts of Germany, Denmark, Sweden, Norway, and all that tract from whence north-eastern winds come, are subject to almost continual frost all the winter; and thereby the lower air is very much condensed, and in that state is brought hitherwards by those winds, and being accumulated by the opposition of the westerly wind blowing in the ocean, the mercury must needs be pressed to a more than ordinary height; and, as a concurring cause, the shrinking of the lower parts of the air into lesser room by cold, must needs cause a descent of the upper parts of the atmosphere, to reduce the cavity made by this contraction to an equilibrium.

"6. After great storms, when the mercury has been very low, it generally rises again very fast: I once observed it to rise one inch and a half in less than six hours, after a long continued storm of south-west wind. The reason is, because the air being very much rarefied, by the great evacuations which such continued storms make thereof, the neighbouring air runs in the more swiftly, to bring it to an equilibrium; as we see water runs the faster for having a greater declivity.

"7. The variations are greater in the more northerly places, as at Stockholm; greater than that at Paris (compared by M. Paschal;) because the more northerly parts have usually greater storms of wind than the more southerly, whereby the mercury should sink lower in that extreme; and then the northerly winds bringing the more dense and ponderous air from the neighbourhood of the Pole, and that again being checked by a southerly wind at no great distance, and so heaped, must of necessity make the mercury in such case stand higher in the other extreme.

"8. Lastly, this remark, that there is little or no variation near the equinoctial, does above all others confirm the hypothesis of the variable winds being the cause of these variations of the height of the mercury; for, in the places above-named, there is always an easy gale of wind blowing nearly upon the same point, viz. east-north-east at Barbadoes, and east-south-east at St. Helena, so that, there being no contrary currents of air to exhaust or accumulate it, the atmosphere continues much in the same state: However, upon hurricanes (the most violent of storms), even the mercury has been observed very low, but this is but once in two or three years, and it soon recovers its settled state, about twenty-nine and a half inches."

MEASUREMENT OF HEIGHTS.

A less common, but very easy and interesting, use of barometrical instruments, is to ascertain the variety of altitudes from the surface of the sea:—to which purpose the Aneroid is, from its portability, exclusively adapted. By the application of this elegant little instrument, an opportunity is afforded the traveller of learning the level of the railway along which he is passing, even at the utmost speed of the engine. It must be allowed, at least, that no *mercurial* barometer can accomplish *this* purpose. The tourist may, by the same means, as he is ascending Snowdon, Ben Lomond, or Mont Blanc, observe the delicate movement of the hand of the Aneroid approaching from the word "Fair" to "Change," as he ascends. So much will this instrument increase the agreeableness of travelling, and supply its possessor with subjects of entertainment and materials for his journal, that it may fairly be anticipated as likely to become the almost indispensable companion of every one who travels either for knowledge or recreation.

An amusing experiment for showing the delicate sensibility of the Aneroid, and its power of measuring small heights, may be tried in an ordinary dwelling-house. Any one, on ascending from the basement to the attic, will perceive the gradual approach of the index from "Fair" to "Change," &c., as noticed above; and its return to its original position, whenever he descends from the attic to the basement. The tenth of an inch is subdivided on the face of the Aneroid into four parts: and generally speaking, if the hand goes back one-tenth of an inch, we may fairly conclude that we have ascended from our starting-point about eighty-five feet; and, of course, *vice versâ*. Calculations will be made according to this proportion.

Those who are desirous of greater philosophical accuracy than is pretended to in describing the popular experiment above suggested, will expect a table to be given them, whereby an approach may be made to more minute exactness.

In this table, the right hand column exhibits numbers in English feet, corresponding to the height of the barometer, shown in the middle column, in inches, tenths, and hundredths; the proportional parts to thousandths are given in the left hand column, A.

BAROMETRIC TABLE.*

A.	Bar. Inch.	English Feet.	A.	Bar. Inch.	English Feet.	A.	Bar. Inch.	English Feet.
+	28·00	27425·3	+	28·20	27611·3	+	28.40	27795·8
0·9	1	27434·6	0·9	1	27620·6	0·9	1	27805·0
1·9	2	27444·0	1·9	2	27629·8	1·8	2	27814·2
2·8	3	27453·3	2·8	3	27639·1	2·8	3	27823·4
3·7	4	27462·6	3·7	4	27648·3	3·7	4	27832·6
4·7	5	27471·9	4·6	5	27657·6	4·6	5	27841·8
5·6	6	27481·3	5·6	6	27666·8	5·5	6	27851·0
6·5	7	27490·6	6·5	7	27676·1	6·4	7	27860·2
7·5	8	27499·9	7·4	8	27685·3	7·4	8	27869·3
8·4	9	27509·2	8·3	9	27694·6	8·3	9	27878·5
+	28·10	27518·4	+	28·30	27703·7	+	28.50	27887·7
0·9	1	27527·7	0·9	1	27712·9	0·9	1	27896·9
1·9	2	27537·0	1·8	2	27722·2	1·8	2	27906·0
2·8	3	27546·3	2·8	3	27731·4	2·7	3	27915·2
3·7	4	27555·6	3·7	4	27740·6	3·7	4	27924·3
4·6	5	27564·9	4·6	5	27749·8	4·6	5	27933·5
5·6	6	27574·2	5·5	6	27759·1	5·5	6	27942·6
6·5	7	27583·5	6·5	7	27768·3	6·4	7	27951·8
7·4	8	27592·7	7·4	8	27777·5	7·3	8	27960·9
8·4	9	27602·0	8·3	9	27786·7	8·2	9	27970·1

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* Being an extract, by permission, from the elaborate table of W. Galbraith, M.A., dedicated to Sir Thomas M. Brisbane, Bart.

A.	Bar. Inch.	English Feet.	A.	Bar. Inch.	English Feet.	A.	Bar. Inch.	English Feet.
+	28·60	27979·2	+	29·10	28432·0	+	29·60	28877·1
0·9	1	27988·3	0·9	1	28441·0	0·9	1	28885·9
1·8	2	27997·5	1·8	2	28450·0	1·8	2	28894·7
2·7	3	28006·6	2·7	3	28458·9	2·6	3	28903·6
3·7	4	28015·7	3·6	4	28467·9	3·5	4	28912·4
4·6	5	28024·8	4·5	5	28476·9	4·4	5	28921·2
5·5	6	28034·0	5·4	6	28485·8	5·3	6	28930·0
6·4	7	28043·1	6·3	7	28494·8	6·2	7	28938·8
7·3	8	28052·2	7·2	8	28503·8	7·0	8	28947·6
8·2	9	28061·3	8·1	9	28512·7	7·9	9	28956·4
+	28·70	28070·5	+	29·20	28521·7	+	29·70	28965·2
0·9	1	28079·6	0·9	1	28530·6	0·9	1	28974·0
1·8	2	28088·7	1·8	2	28539·6	1·8	2	28982·8
2·7	3	28097·8	2·7	3	28548·5	2·6	3	28991·6
3·6	4	28106·9	3·6	4	28557·5	3·5	4	29000·4
4·5	5	28115 9	4·5	5	28566·4	4·4	5	29009·1
5·5	6	28125·0	5·4	6	28575·4	5·3	6	29017·9
6·4	7	28134·1	6·3	7	28584·3	6·1	7	29026·7
7·3	8	28143·2	7·2	8	28593·2	7·0	8	29035·5
8·2	9	28152·2	8·0	9	28602·2	7·9	9	29044·2
+	28·80	28161·3	+	29·30	28611·1	+	29·80	29053·1
0·9	1	28170·4	0·9	1	28620·0	0·9	1	29061·9
1·8	2	28179·4	1·8	2	28628·9	1·8	2	29070·6
2·7	3	28188·5	2·7	3	28637·8	2·6	3	29079·4
3·6	4	28197·5	3·6	4	28646·7	3·5	4	29088·1
4·5	5	28206·6	4·5	5	28655·6	4·4	5	29096·9
5·4	6	28215·6	5·3	6	28664·5	5·3	6	29105·6
6·3	7	28224·7	6·2	7	28673·4	6·1	7	29114·4
7·2	8	28233·7	7·1	8	28682·3	7·0	8	29123·1
8·1	9	28242·8	8·0	9	28691·2	7·9	9	29131·9
+	28·90	28251·8	+	29·40	28700·0	+	29·90	29140·6
0·9	1	28260·8	0·9	1	28708·9	0·9	1	29149·3
1·8	2	28269·9	1·8	2	28717·8	1·7	2	29158·1
2·7	3	28278·9	2·7	3	28726·6	2·6	3	29166·8
3·6	4	28287·9	3·6	4	28735·5	3·5	4	29175·5
4·5	5	28296·9	4·4	5	28744·4	4·4	5	29184·2
5·4	6	28306·0	5·3	6	28753·3	5·2	6	29193 0
6·3	7	28315·0	6·2	7	28762·1	6·1	7	29201·7
7·2	8	28324·0	7·1	8	28771·0	7·0	8	29210·4
8·1	9	28333·0	8·0	9	28779·9	7·8	9	29219·1
+	29·00	28342·1	+	29·50	28788·7	+	30·00	29227·8
0·9	1	28351·1	0·9	1	28797·5	0·9	1	29236·5
1·8	2	28360·1	1·8	2	28806·4	1·7	2	29245·2
2·7	3	28369·1	2·7	3	28815·2	2·6	3	29253·9
3·6	4	28378·1	3·5	4	28824·1	3·5	4	29262·6
4·5	5	28387·1	4·4	5	28832·9	4·3	5	29271·3
5·4	6	28396·1	5·3	6	28841·8	5·2	6	29280·0
6·3	7	28405·0	6·2	7	28850·6	6·1	7	29288·7
7·2	8	28414·0	7.1	8	28859·4	7·0	8	29297·3
8·1	9	28423·0	8·0	9	28868·3	7·8	9	29306·0

A.	Bar. Inch.	English Feet.	A.	Bar. Inch.	English Feet.	A.	Bar. Inch.	English Feet.
+	30·10	29314·7	+	30·40	29573·8	+	30·70	29830·2
0·9	1	29323·4	0·9	1	29582·4	0·9	1	29838·7
1·7	2	29332·0	1·7	2	29591·0	1·7	2	29847·2
2·6	3	29340·7	2·6	3	29599·6	2·5	3	29855·7
3·5	4	29349·2	3·4	4	29608·2	3·4	4	29864·2
4·3	5	29358·0	4·3	5	29616·7	4·3	5	29872·7
5·2	6	29366·7	5·2	6	29625·3	5·1	6	29881·2
6·1	7	29375·3	6·0	7	29633·9	6·0	7	29889·7
6·9	8	29384·0	6·9	8	29642·5	6·8	8	29898·2
7·8	9	29392·6	7·7	9	29651·0	7·7	9	29906·7
+	30·20	29401·3	+	30·50	29659·6	+	30·80	29915·2
0·9	1	29409·9	0·9	1	29668·1	0·8	1	29923·7
1·7	2	29418·6	1·7	2	29676·7	1·7	2	29932·2
2·6	3	29427·2	2·6	3	29685·2	2·5	3	29940·7
3·5	4	29435·9	3·4	4	29693·8	3·4	4	29949·2
4·3	5	29444·5	4·3	5	29702·3	4·2	5	29957·6
5·2	6	29453·2	5·1	6	29710·9	5·1	6	29966·1
6·1	7	29461·8	6·0	7	29719·4	5·9	7	29974·6
6·9	8	29470·4	6·8	8	29727·9	6·8	8	29983·1
7·8	9	29479·1	7·7	9	29736·5	7·6	9	29991·5
+	30·30	29487·7	+	30·60	29745·0	+	30·90	30000·0
0·9	1	29496·3	0·9	1	29753·5	0·8	1	30008·5
1·7	2	29504·9	1·7	2	29762·1	1·7	2	30016·9
2·6	3	29513·6	2·6	3	29770·6	2·5	3	30025·4
3·4	4	29522·2	3·4	4	29779·1	3·4	4	30033·8
4·3	5	29530·8	4·3	5	29787·6	4·2	5	30042·3
5·2	6	29539·4	5·1	6	29796·2	5·1	6	30050 7
6·0	7	29548·0	6·0	7	29804·7	5·9	7	30059·2
6·9	8	29556·6	6·8	8	29813·2	6·8	8	30067·6
7·7	9	29565·2	7·7	9	29821·7	7·6	9	30076·1

Example.—It is required to find, in English feet, the difference of level between Dover and Folkstone Railway-stations by the barometer, Dover being indicated 30·125 inches, Folkstone 30·000. In the table at 30·12 we find 29332·0, and in the column A at 5 we have 4·3 ; which, added to 29332·0, gives for Dover 29336·3. On referring to the 30·000 inches in the table, by which Folkstone is indicated, we find 29227·8. The one, subtracted from the other, gives the difference in feet between the two stations ; *e. g.*—

Dover	29336·3
Folkstone	29227·8
Feet .	108·5

Folkstone-station, therefore, is higher than that at Dover by 108·5 feet.

The above experiment was actually made by the writer while sitting in a railway-carriage, and the example will serve as a guide for taking any measurement by the barometer.

The natural philosopher is enabled, by means of the Aneroid, to discover the quantity necessary for thermometrical correction. He has only to expose the instrument to the temperature of the external air, (having set the hands in coincidence,) and afterwards place it before the fire, until the thermometer is at 100. Any variation of the hand, divided by the degrees of the thermometer, will give the quantity for each degree. It is not saying too much for this instrument, to assert that the quantity to be allowed does not generally equal what is necessary for the correction of the mercurial barometer. The amount will be sometimes in defect, and at others in excess. So nearly is the Aneroid compensated for varying temperatures.

NAUTICAL USE OF THE ANEROID.

But to no class of persons will the Aneroid offer advantages so great and so pre-eminently important as to the mariner, when we consider the life and property intrusted to his care, and the influence of the atmosphere on his safety. He knows too well, by experience, not only the tardy indications he is forced to be content with, from the sluggish action of the barometer in general use, but the difficulty of reading off those indications with exactness, when the vessel is in considerable motion. The Aneroid, on the contrary, responds in a moment to the influence of atmospheric pressure ; and this it does without any oscillation of the hand, that may occasion the least doubt in the observer. Nothing is more common than a sudden variation of atmospheric pressure to the amount of nearly half an inch on the barometer. To point out this would, in the ordinary instrument, inevitably occupy some minutes, while the mercury was forcing itself up or down the capillary tube towards the point which is to give indication. As an exemplification, it may not be amiss to lay before the nautical man the case of his being, while in his cabin, made sensible, by means of the Aneroid, of a sudden change likely to take place in the state of the atmosphere. An important alteration might be immediately necessary in the adjustment of sails, &c., which, by the timely information afforded him through the Aneroid, he would at once have accomplished, long before the common Marine Barometer had even signified the coming change. Instead of being obliged to proceed backwards and forwards from the deck to his cabin to consult the Mercurial Barometer, he remains on deck with the Aneroid in his hand, and is immediately certified of every atmospheric variation while he is issuing orders to the ship's company. A result more desirable than that which is here supposed, cannot, perhaps, be easily contemplated; and yet it is one which, it is confidently asserted, the new instrument in question cannot fail to produce.

The Aneroid, though a hardy instrument, if compared with a watch or clock, is yet too delicate in its structure to admit of carelessness or rough usage. The only indispensable caution, however, appears to be. that attention be paid to protect it from a fall; not only to secure the glass from breaking, but because a smart concussion might remove the lever C, and so disturb the position of the hand as to prevent its pointing to the proper indications. It may, at the same time. be remarked, that the derangement occasioned by such an accident would be so simple and so easily remedied, that little or no expense would result from it. The effects of a slight concussion may be rectified without having recourse to the maker, by merely turning the screw A in the direction which will bring back the hand to its proper place. For this purpose, the Aneroid which has been deranged by the accident, must be set by another barometer. This caution, however, is not necessary, when its use is confined merely to indicate change of weather; for in this case, if the hand, by turning the screw A, be placed at the word "Change," the Aneroid will be as serviceable to show varying atmospheric pressure, as though it agreed with a standard barometer. It should be added, that no one ought to alter the hand of his Aneroid without having ascertained the character of the barometer by which he purposes to set it; just as it would be absurd in any one to alter his watch, that it might correspond with a timekeeper notoriously defective.

The Aneroid, closely packed in hay, and secured by the precautions usually adopted in transmitting glass, may be sent to its place of destination, however distant, with the most perfect safety.

THE END.

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